Operative Techniques in
Thoracic and
Cardiovascular Surgery

Ablation of Atrial Fibrillation with Concomitant Surgery

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Atrial fibrillation (AF) is associated with increased morbidity and mortality in coronary artery bypass graft and mitral valve patients.[1,2] The Cox maze III operation, or maze procedure, is considered the gold standard for the surgical treatment of AF. In this procedure, multiple left and right atrial incisions and cryolesions are placed to interrupt the re-entrant circuits of AF. Although the success of the Cox maze III operation exceeds 90%, the complexity of the traditional "cut-and-sew" procedure hindered its widespread application.[3] Over the past decade, newer technologies have allowed surgeons to ablate AF with the use of different energy sources and much simpler techniques. Various technologies have allowed the creation of transmural lesions, which recapitulate the incisions in the tradition Cox maze III operation in only a few minutes of operative time.[4,5]

Bipolar radiofrequency (RF) energy is an alternating electrical current that results in heat propagation and the creation of transmural cardiac lesions that histologically resemble the healed incisions of the traditional Cox maze III operation. The bipolar nature of the current ensures directionality that minimizes collateral tissue damage and creates a localized lesion. Additionally, bipolar RF devices have the capability of establishing transmurality feedback that can be used to control energy delivery.

The choice of the lesion set in the right and left atria influences the success of the surgical ablative procedure.[6] In most patients, a bi-atrial lesion set is associated with the greatest freedom from AF. The important left atrial lesions include bilateral pulmonary vein isolation, connecting lesions between each set of pulmonary veins to complete a "box lesion," and connecting lesions to the mitral valve annulus and left atrial appendage. The lesion between the pulmonary veins and the mitral valve annulus is important for the prevention of left atrial flutter and recurrent AF postoperatively.[7] We also incorporate a right atrial lesion set in view of recent data supporting a better long-term chance at maintaining sinus rhythm in patients who had bi-atrial lesions. Finally, excision of the left atrial appendage is a central component of the treatment of AF because 60% to 90% of stroke-causing emboli in patients with AF originate in the left atrial appendage.

The following is our technique for the surgical treatment of AF in patients having concomitant cardiac surgery.

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1522-2942/09/$-see front matter
doi:10.1053/j.optechstcvs.2009.06.004

Operative Technique

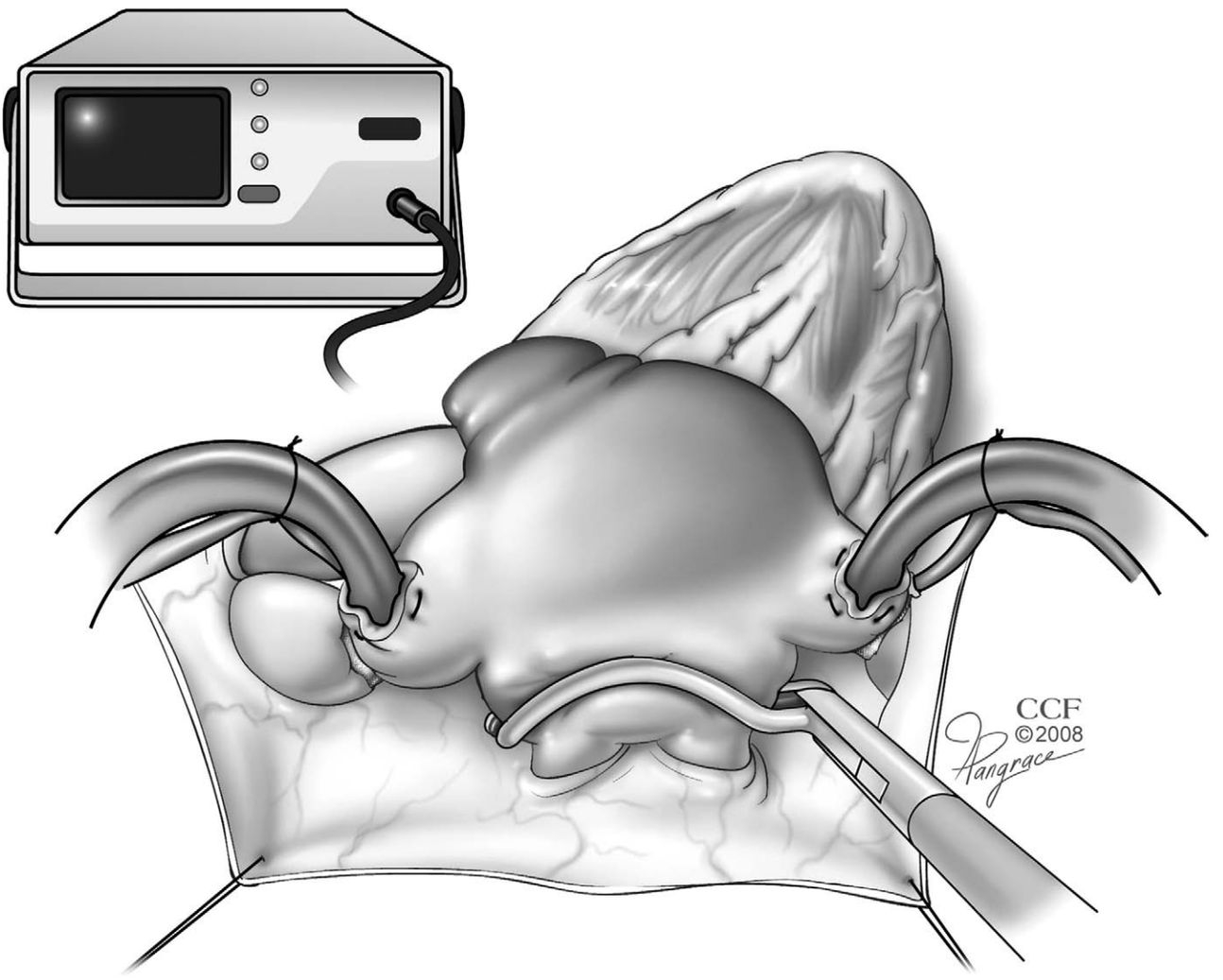

Figure 1 A standard median sternotomy is performed and cardiopulmonary bypass is initiated with bicaval and ascending aortic cannulation. Pulmonary vein isolation is performed on the beating, decompressed heart; doing so on the beating heart enables assessment of conduction block. The right pulmonary veins are addressed first. The posterior surface of the right pulmonary veins is dissected bluntly, and fat along the anterior surface is dissected with cautery to enable the surgeon to perform a wide pulmonary vein isolation that includes adjacent left atrial tissue. A pacing probe is then placed on the pulmonary veins and the pacing threshold is established; if the patient is in AF, cardioversion is performed before attempting to assess the pacing threshold. A bipolar RF clamp (Atricure Inc., West Chester, OH) is then introduced around the pulmonary veins beginning from the inferior vein. The clamp is advanced toward the left atrium, isolating as much atrial tissue as possible and ensuring that energy is not delivered directly to the pulmonary vein tissue because this may cause pulmonary vein stenosis. Two parallel 5- to 15-second applications of the RF clamp are made to ensure that there are no gaps in the isolation. Exit block is then confirmed by attempting to entrain the heart by pacing from the pulmonary veins. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

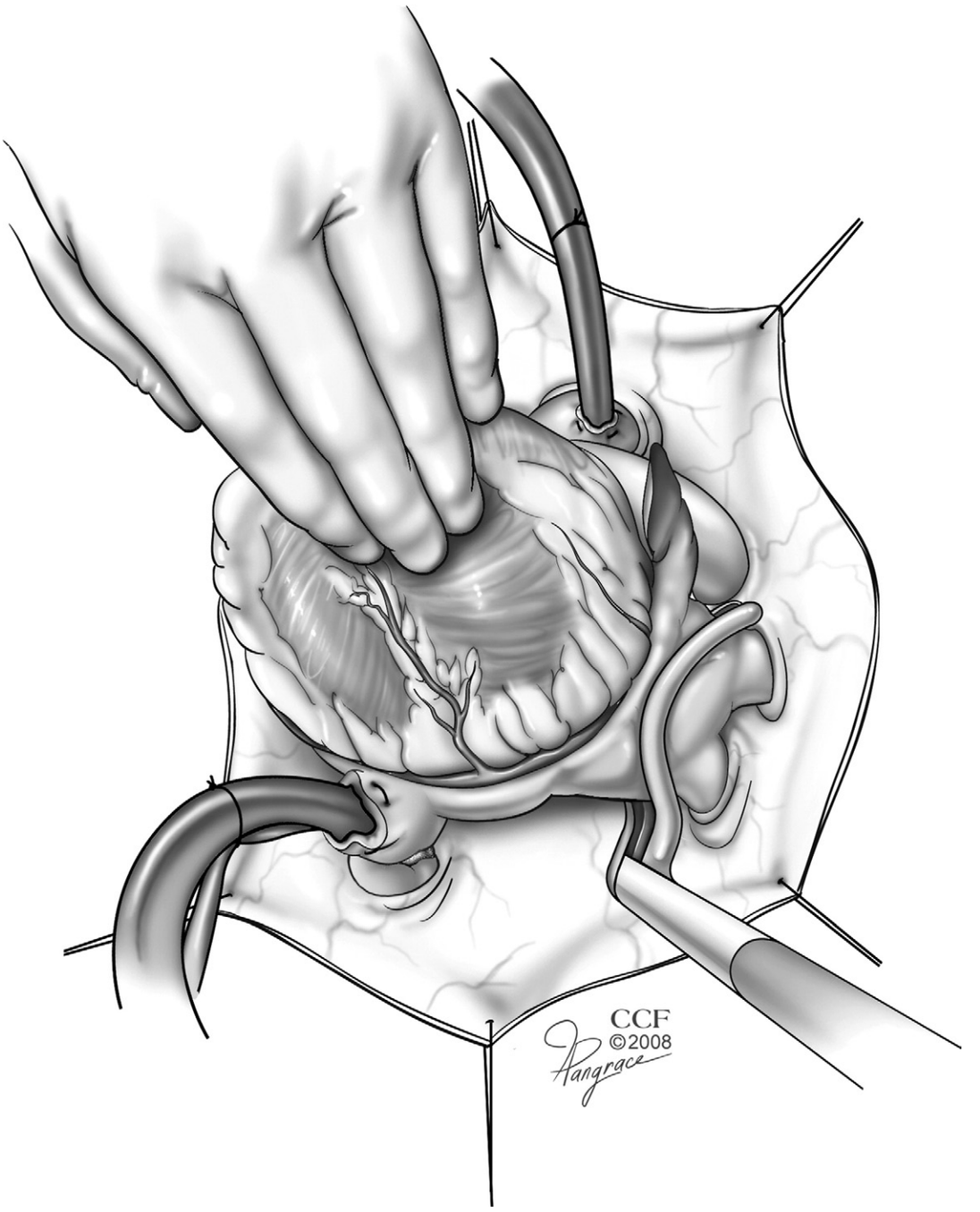

Figure 2 The heart is retracted to the right to expose the left pulmonary veins. Pericardial stay sutures on the right should be loosened to improve this exposure. The posterior surface of the left pulmonary veins is likewise dissected, including the ligament of Marshall, the fibrous band coursing from the coronary sinus to the superior pulmonary vein. As with the right pulmonary veins, the pacing threshold is established. The bipolar RF clamp is introduced around the pulmonary veins beginning inferiorly and positioned so as to include as much left atrial tissue as possible. Again, 2 parallel 5- to 15-second applications of the RF clamp are made. Exit block is confirmed by pacing from the pulmonary veins. The heart is then arrested with antegrade and retrograde cardioplegia. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

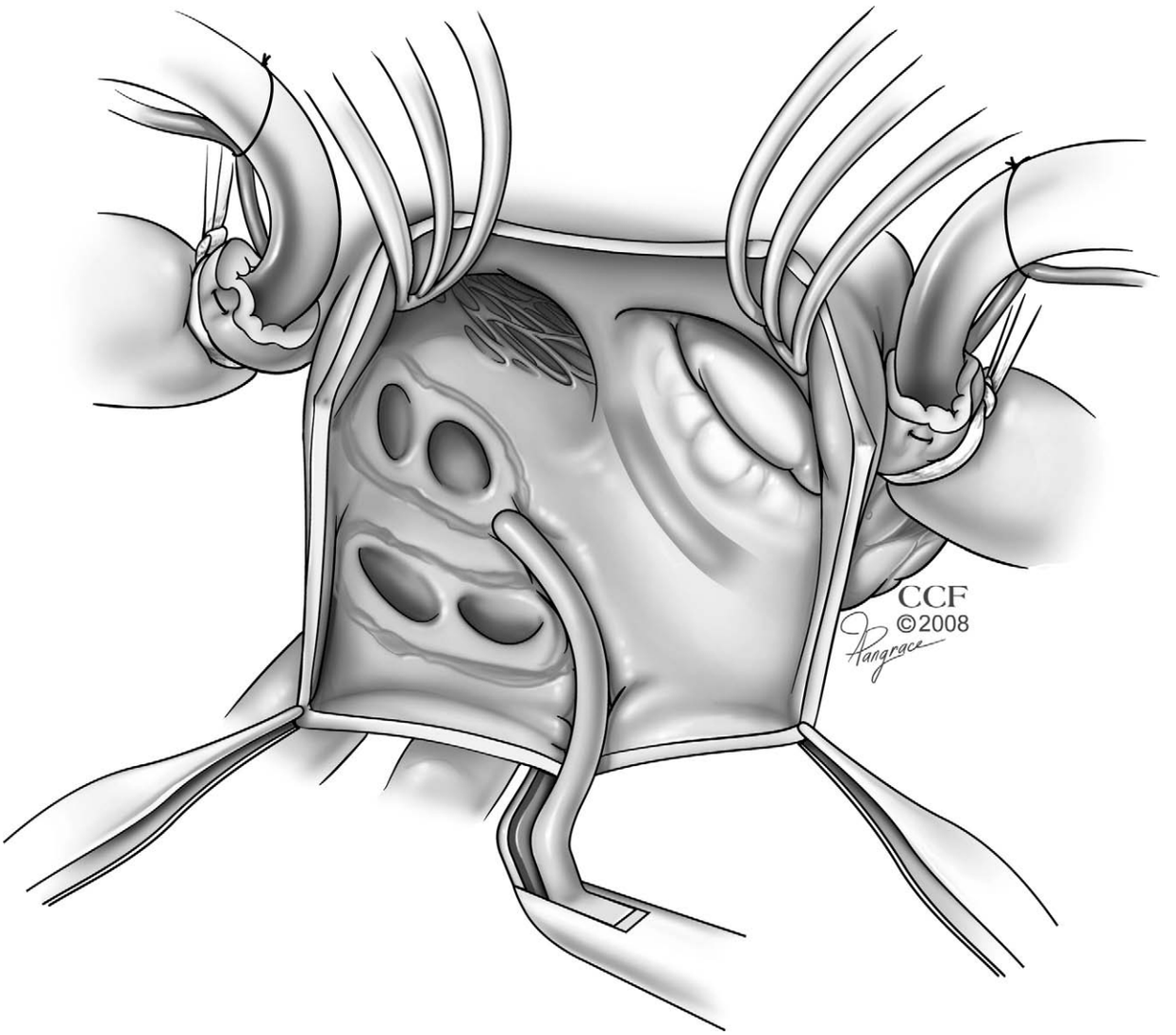

Figure 3 A standard left atriotomy is performed anterior to the right pulmonary veins in Sondergaard's groove. A self-retaining retractor is used to facilitate exposure of the left atrium during successive RF clamp applications. The RF clamp is used to create connecting lesions between the right and left pulmonary veins. The RF clamp is used to connect first the inferior veins with one 5- to 15-second application of the RF clamp. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

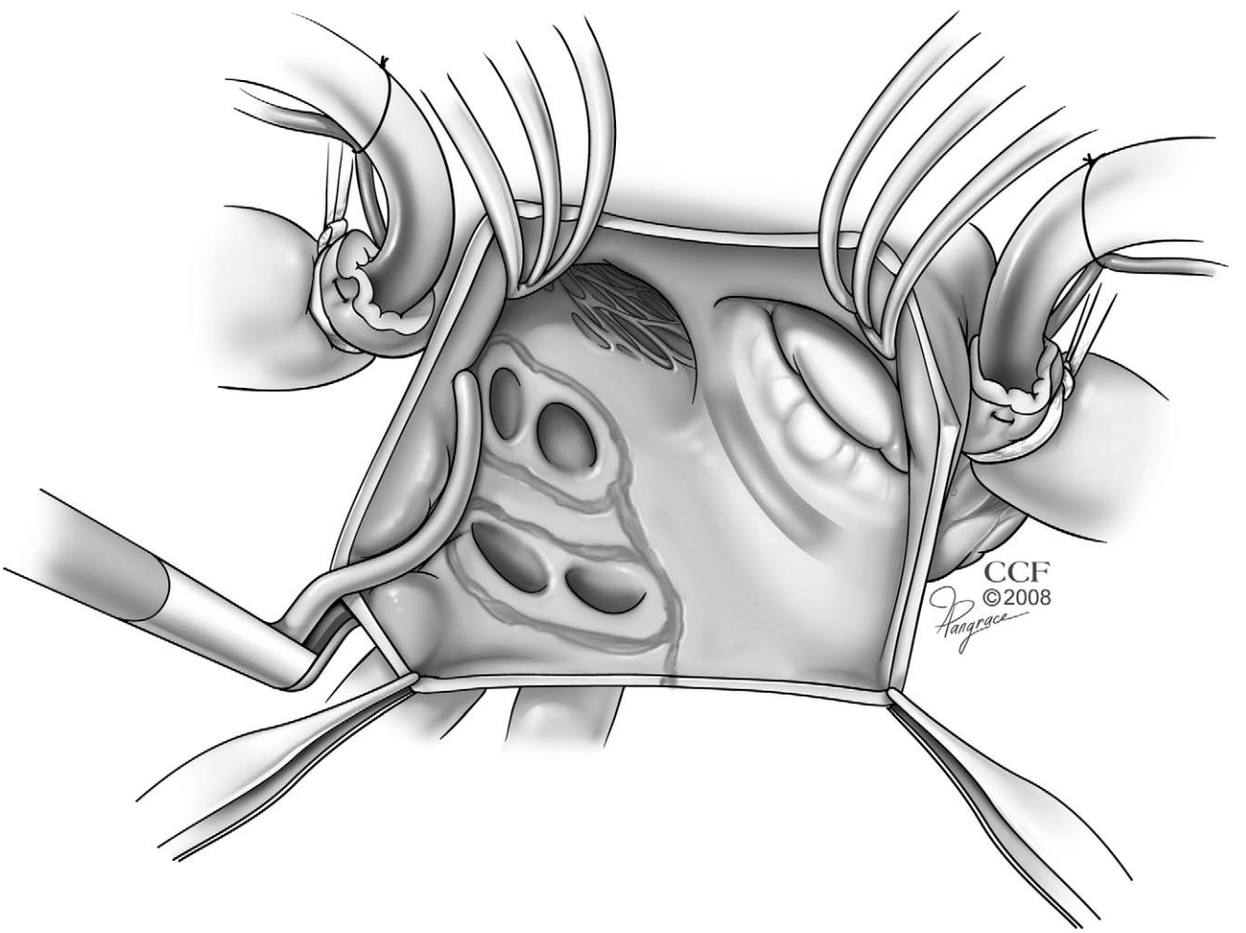

Figure 4 The connecting lesion between the superior pulmonary veins is then created with another 5- to 15-second application of the RF clamp. This completes the "box lesion" in the posterior left atrium. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

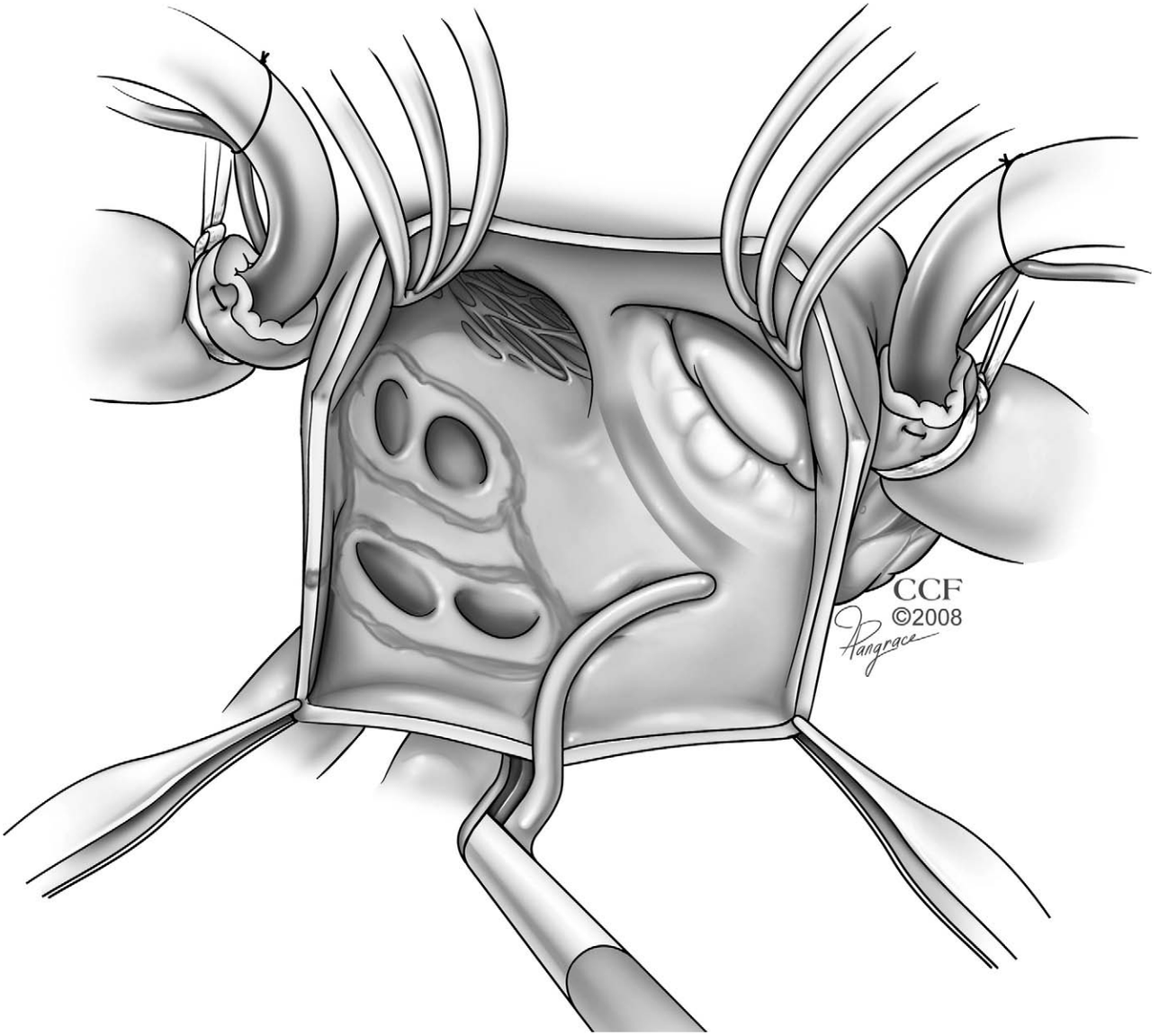

Figure 5 A combination of bipolar RF and cryothermy is then used to create a connecting lesion from the right inferior pulmonary vein to the P3 region of the mitral annulus. The retrograde catheter should not be in place during creation of this lesion. The first part of the lesion is created with bipolar RF, the clamp angled toward the P3 segment of the mitral valve but not reaching the AV groove. Here, care should be used in applying the RF clamp so as to avoid the circumflex coronary artery, which parallels the posterior mitral annulus. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

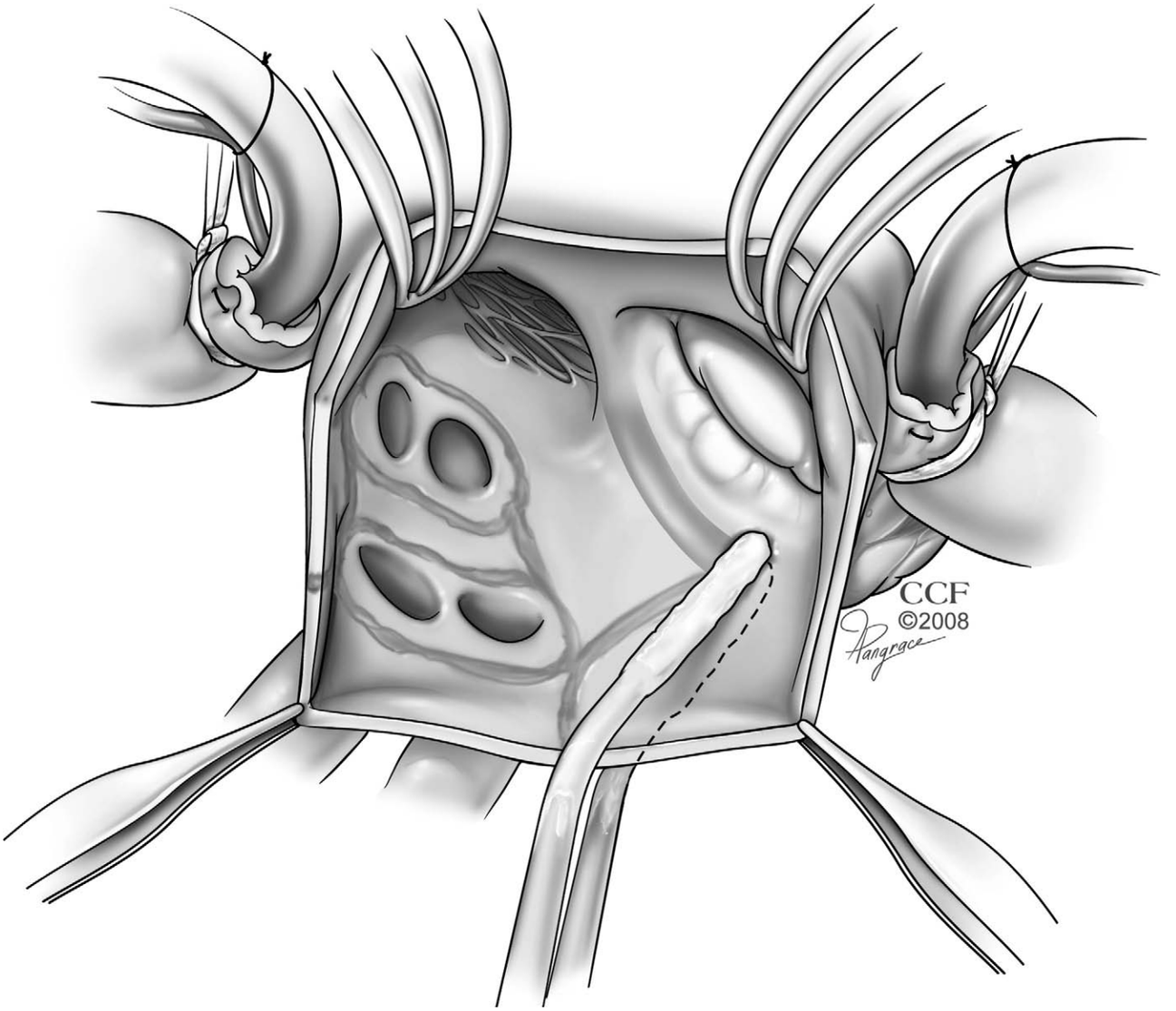

Figure 6 At the mitral annulus, the lesion is completed with cryothermy. The coronary sinus and mitral annulus are "sandwiched" between 2 long, 5-mm cryoprobes, ensuring a transmural lesion. This lesion is performed using nitrous-oxide-based cryothermy at −60°C for 2 minutes. Appropriate thawing of the tissue is necessary before removing the cryoprobes to avoid tearing the tissue. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

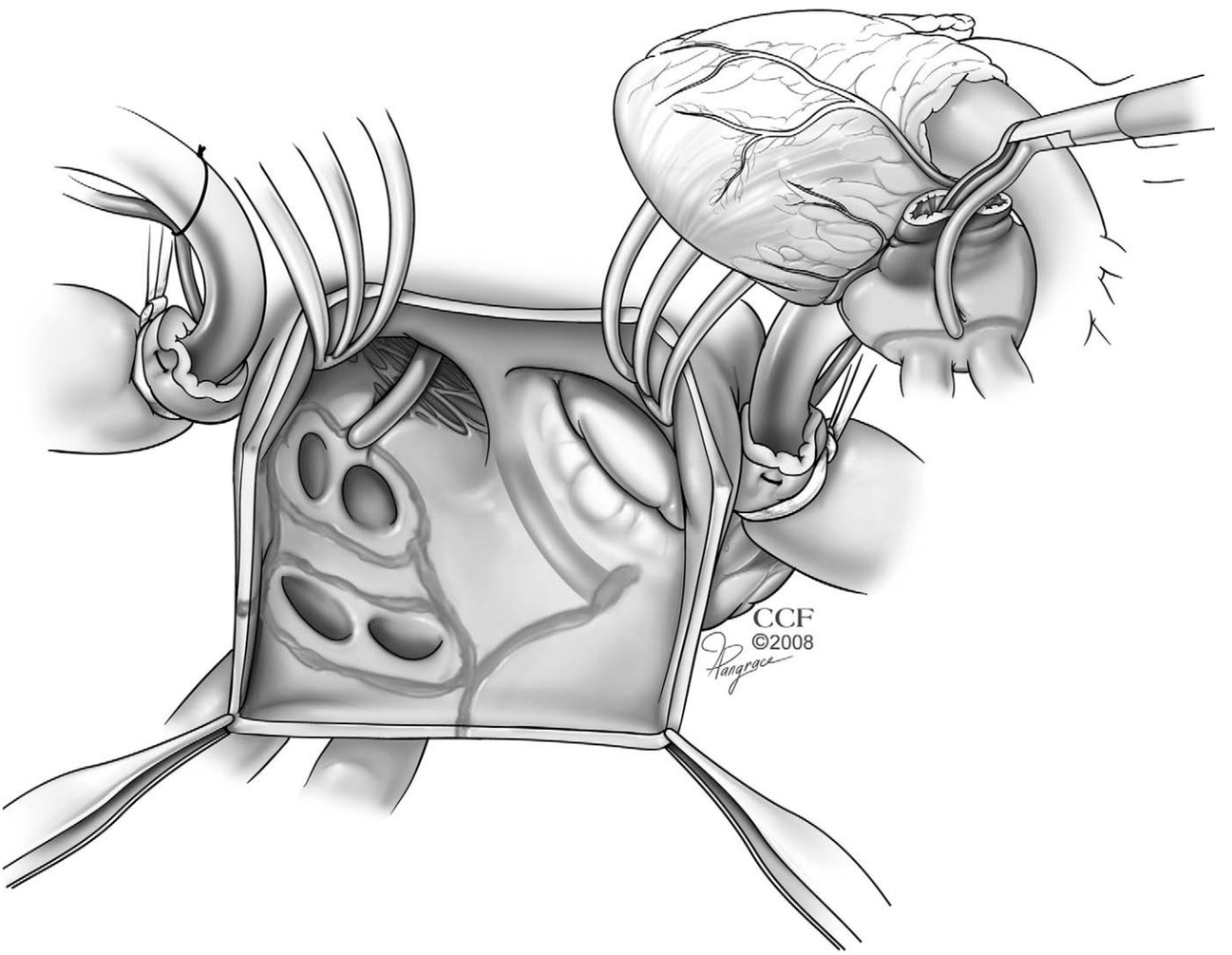

Figure 7 Completion of the left atrial lesion set is accomplished by retracting the heart to the right after loosening the right-sided pericardial stay sutures. The left atrial appendage is excised with cautery, leaving a rim distal to its base to facilitate secure closure without impingement on the circumflex coronary artery. The RF clamp is advanced through the excised left atrial appendage, directing the tips of the clamp toward the left pulmonary vein encircling the lesion. This RF lesion connects the left atrial appendage to the pulmonary vein isolating the lesion. The left atrial appendage stump is then closed with 2 layers of running polypropylene suture. Postoperative thromboembolism has been reported when the left atrial appendage is not completely excised. Finally, the left atriotomy is closed with polypropylene suture, starting at each end and running to the middle. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

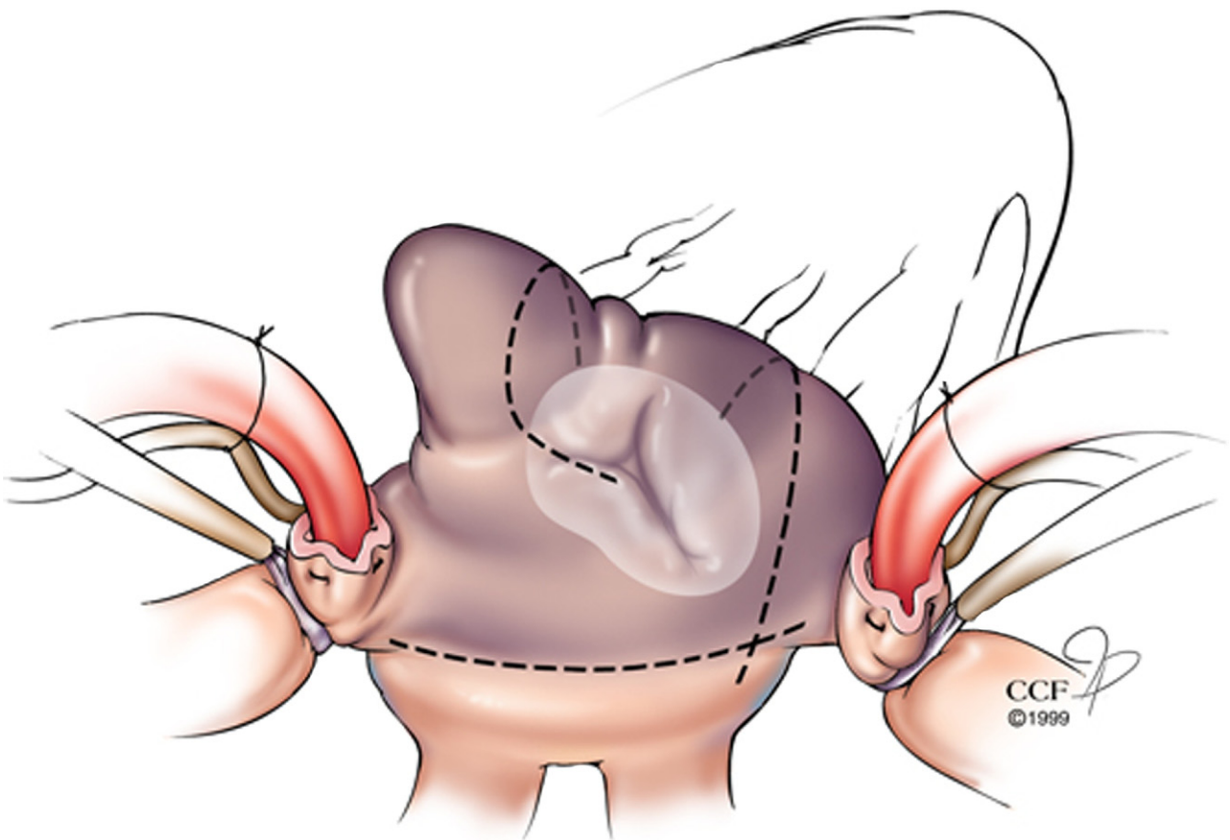

Figure 8 The right atrial lesion set includes an intercaval lesion, and 2 separate lesions to the tricuspid annulus. We prefer to create the right atrial lesions with the heart arrested, although the lesions may be created on the beating, decompressed heart. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

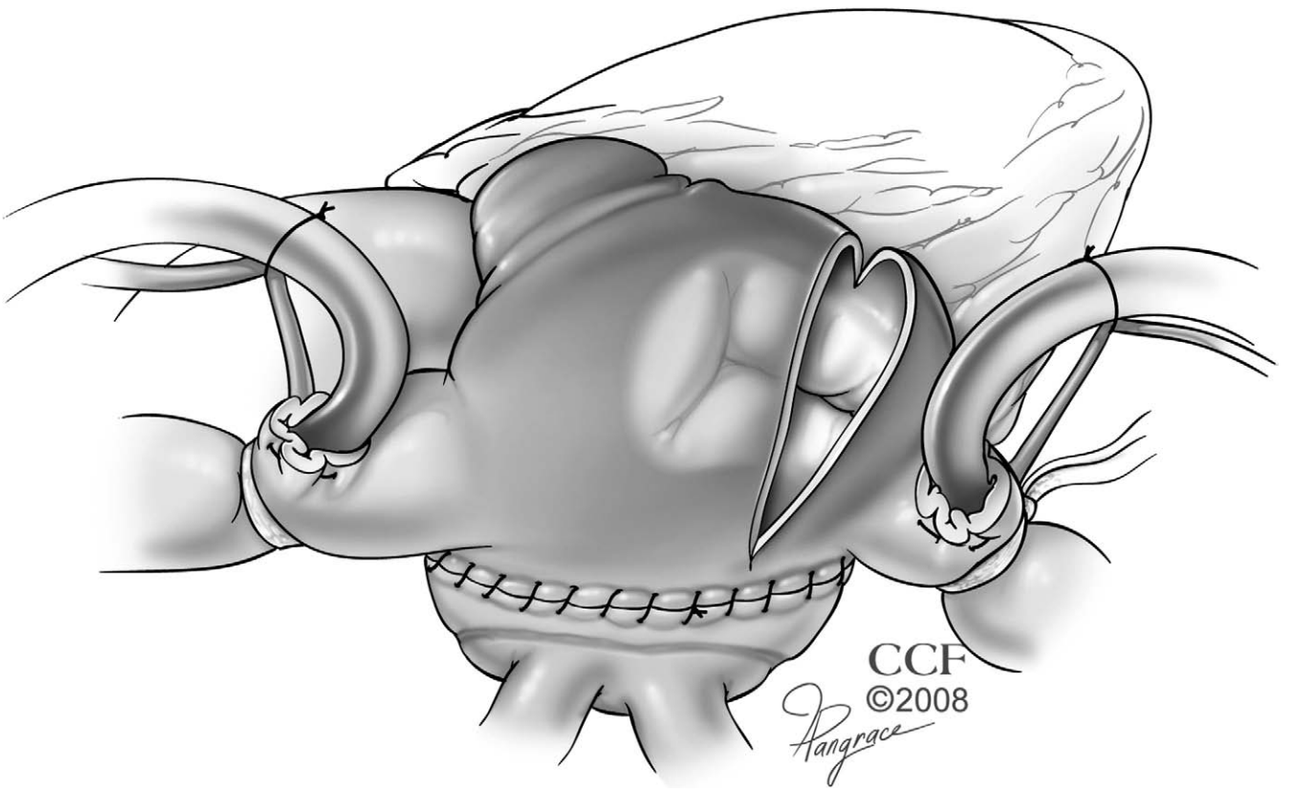

Figure 9 After securing the caval snares, the right atrium is opened with an incision that extends from the tricuspid annulus (2 o'clock position as the surgeon views the valve) toward the fossa ovalis. This is the same incision that should be used for placement of the retrograde cardioplegia catheter if it is placed directly into the coronary sinus at the beginning of the case. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

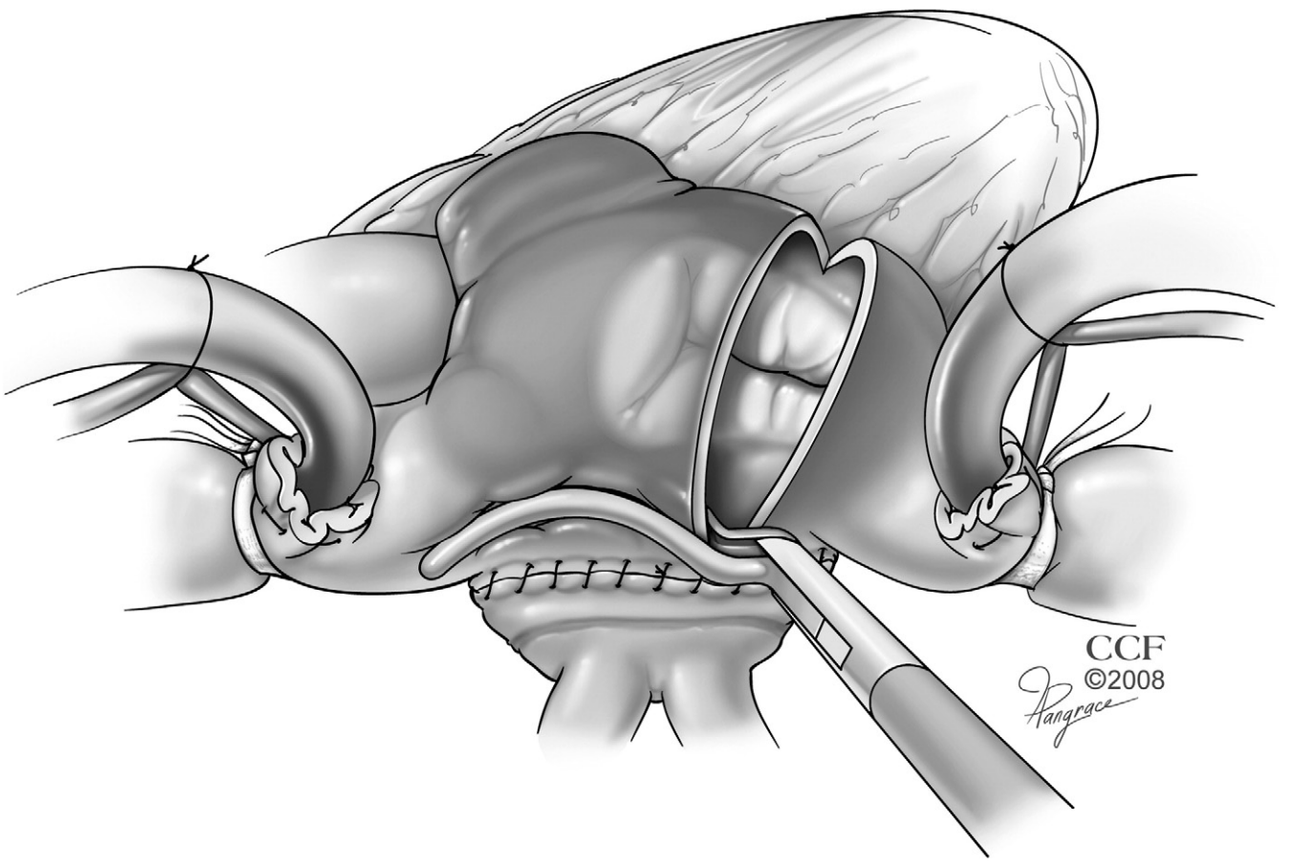

Figure 10 From the inferior aspect of the right atriotomy, the bipolar RF clamp is placed up to the superior vena cava, and a lesion is created extending onto the caval tissue. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

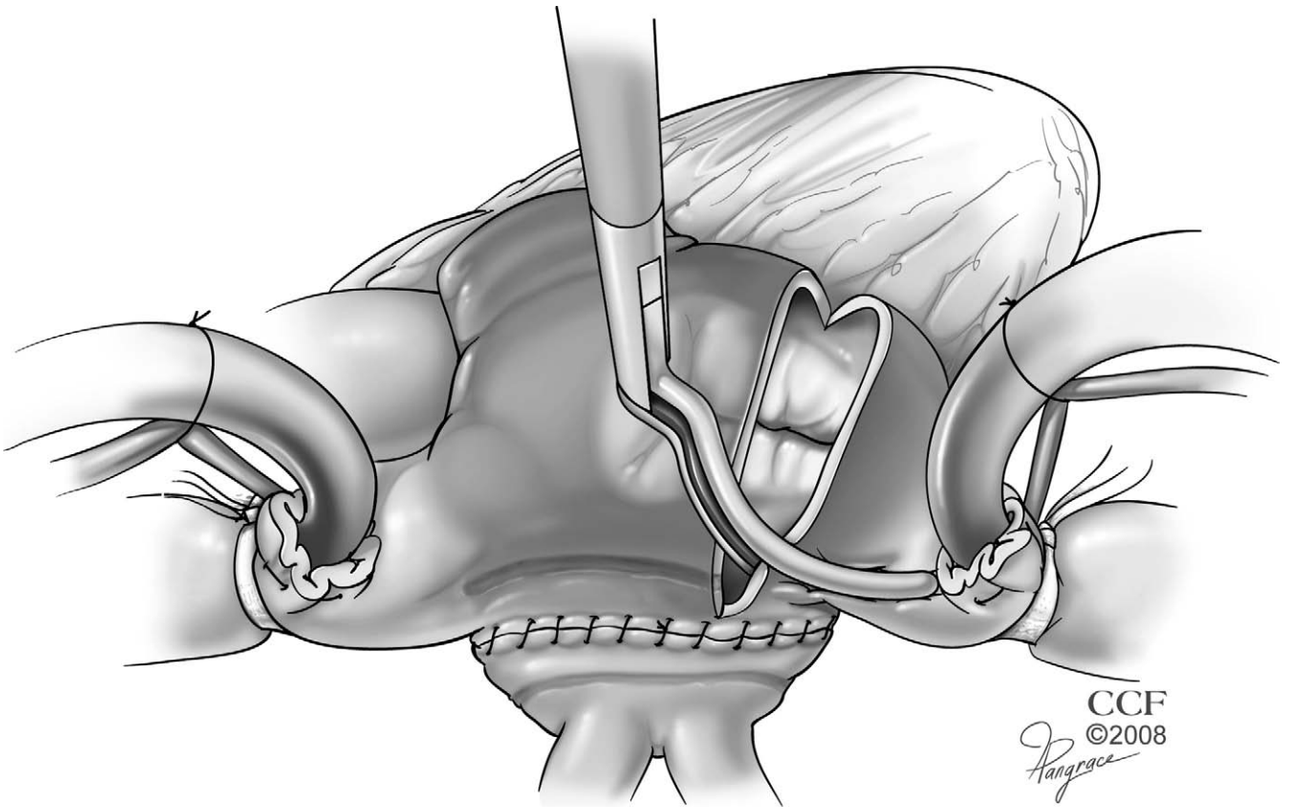

Figure 11 The clamp is then rotated 180° and a second application of the clamp is used to make a lesion to the inferior vena caval tissue. This creates a full right atrial lesion between both cavae. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

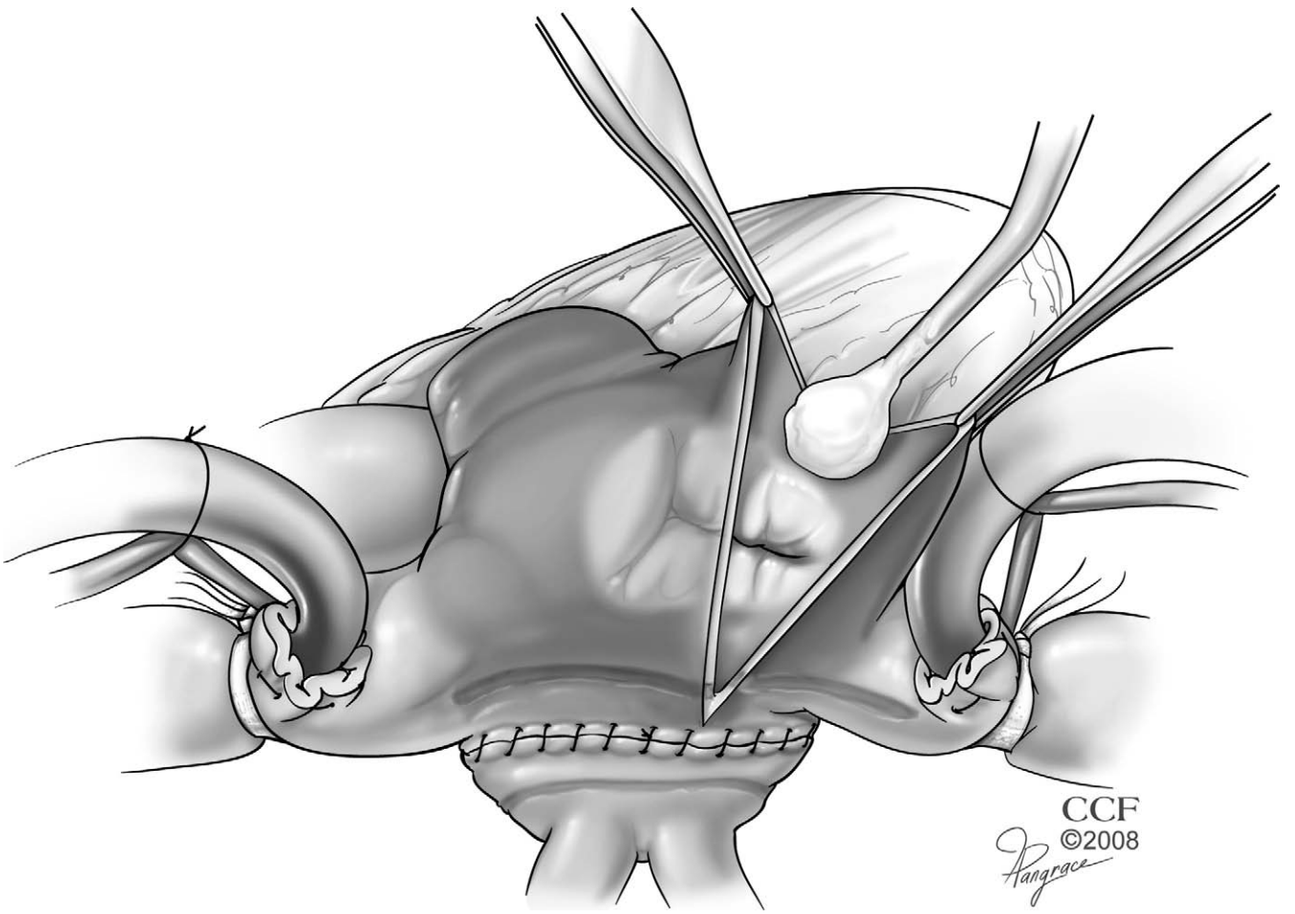

Figure 12 A 2-minute cryolesion is then created at the 2 o'clock position of the tricuspid annulus. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

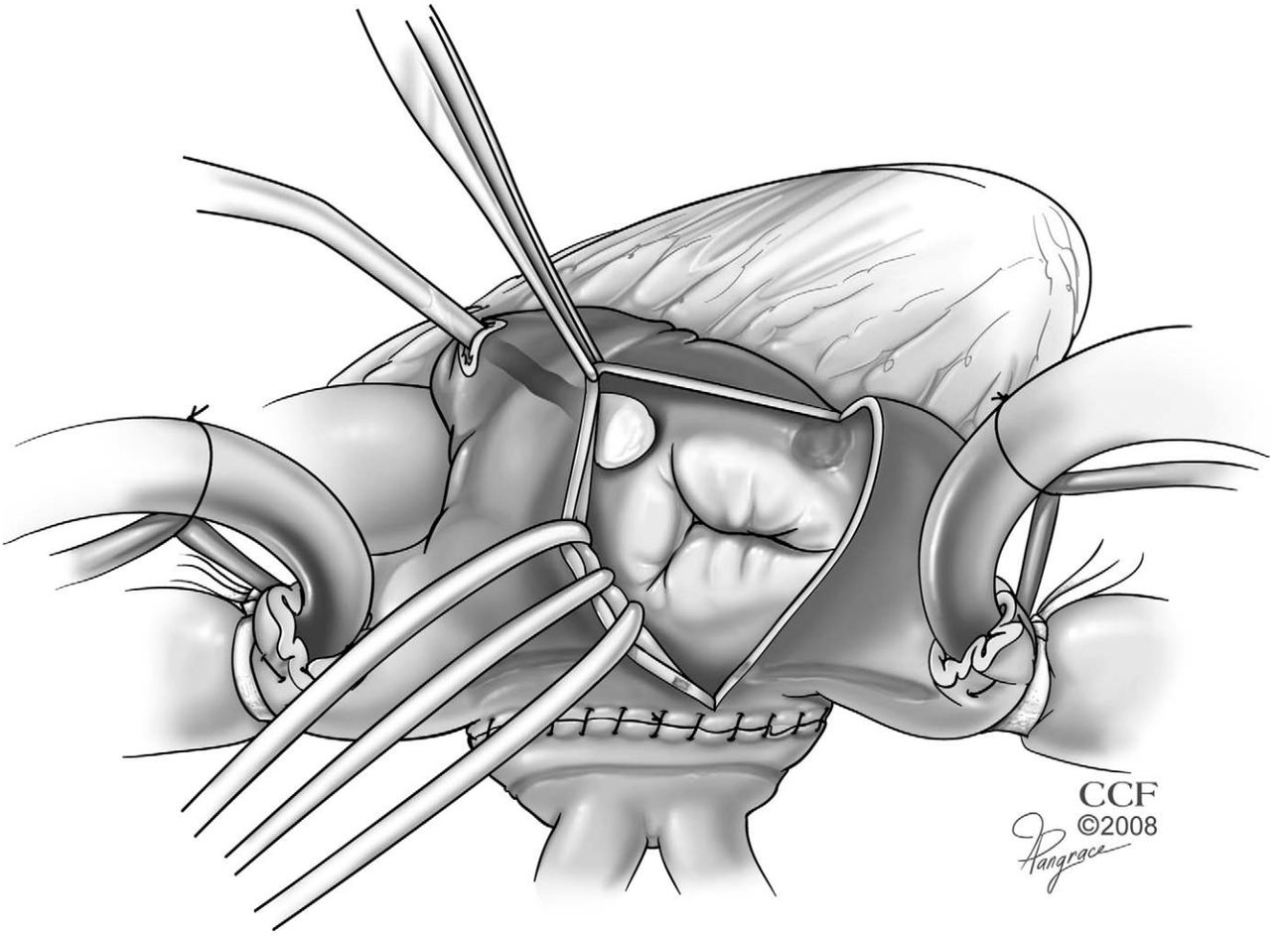

Figure 13 A separate stab incision is then created in the right atrial appendage through which the cryoprobe is passed to create another cryolesion at the 10 o'clock position of the tricuspid annulus. Alternatively, some surgeons prefer to create a single right atrial lesion extending from the tricuspid annulus to the inferior vena cava. This right atrial isthmus line is effective at treating or preventing typical right atrial flutter. We do not recommend creation of this lesion in addition to the other right atrial lesions of the Cox maze III lesion set. The right atrial incisions are closed with running polypropylene suture after the aortic cross-clamp is removed.

It is prudent to examine the left atrial appendage stump suture line while still on cardiopulmonary bypass because it is most easily repaired before weaning from bypass. Temporary atrial and ventricular pacing wires are placed as many patients develop a transient nodal rhythm postoperatively. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1999-2009. All rights reserved.)

Postablation Care

Periprocedural AF occurs in 30% to 60% of patients after surgical ablation. Similar to routine postoperative AF, this arrhythmia is usually transient; by 3 months after surgery, more than 80% of these patients have returned to normal sinus rhythm. When postablation AF does occur, we treat patients with standard anti-arrhythmic medications such as amiodarone for 4 to 6 weeks. A single electrical cardioversion is attempted in hospital to restore sinus rhythm if anti-arrhythmic drugs do not convert a patient. All patients are discharged on Coumadin with a goal INR of 2.0 for 6 months, during which transtelephonic rhythm monitoring takes place. If patients have no evidence of AF at 6 months, Coumadin is discontinued. Electrical cardioversion is attempted at 3 months postoperatively for patients who remain in atrial fibrillation. At 1 year, this bi-atrial lesion set results in approximately 90% freedom from AF in patients with paroxysmal AF and 80% freedom from AF in those with persistent AF; age, AF duration, and left atrial size also influence results.

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